Estrategias de control de la lixiviación de nitratos: empleo de cultivos cubierta y NTOOLBOX

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- Proyecto NTOOLBOX:
  - Catálogo de estrategias para control de la lixiviación de nitratos
  - NDICEA: Modelo de simulación del balance de N en sistemas de cultivo

Introduction

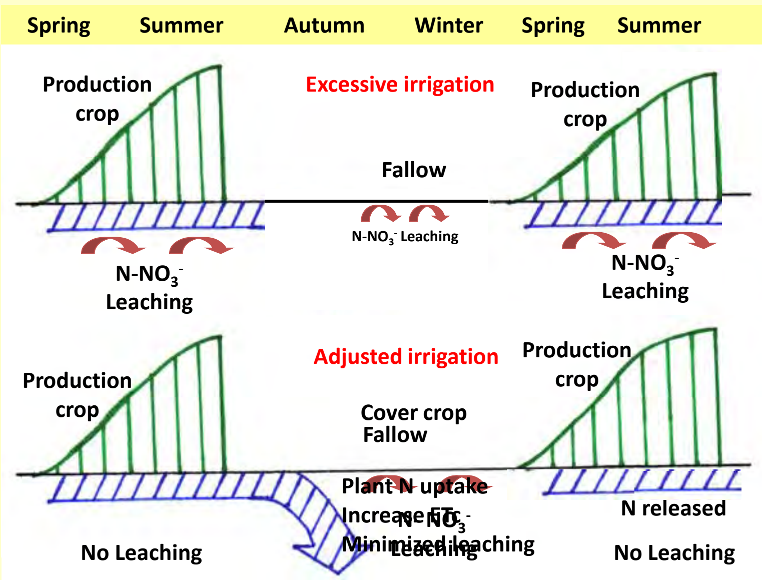
Cultivos cubierta

• Introducidos en sistemas de cultivo para aumentar la sostenibilidad sin buscar *a priori* un beneficio económico

•beneficios:

- ✓Control erosión suelo
- ✓Mejora calidad suelo
- ✓Reciclaje de nutrientes
- ✓Control de malas hierbas, plagas y enfermedades
- ✓Reducir la lixiviación de nitratos

Empleo de cultivos cubierta en sistemas de regadío



Objectivos

Estudiar el efecto de reemplazar el barbecho con cultivos cubierta en sistema intensivos de regadío.

Nos centramos en sistemas de cultivo de maíz:

- productividad del cultivo y N absorbio por el CC y maiz

- eficiencia de uso del N y fertilizante recuperado

- acumulación de N mineral en el suelo

- balance de agua y lixiviación nitratos

Material and methods

Farm "La Chimenea" **Location: Aranjuez, Taxus river Valley**

Climate: Dry Mediterranean, monoxeric (June-Septembre)

- Mean temperature: 20.5 ºC, maximum ,14 ºC and minimum 6.5 ºC
- Mean rainfall: 450 mm
- ETo=753 mm

Material and methods

AgSystems

Soil characteristics

Ocric
Ap: 0-23 cm
A: 23-40 cm

Cambic
B: 40-70 cm

Calcic
Bk: 70-120 cm

Clasification
- **Typic calcixerept** (Soil Survey Staff, 2003)
- **Calcisol háplico** (FAO-UNESCO, 1988)

pH ~ 8
High to medium organic C and carbonates
Texture: silty clay loam
Good permeability

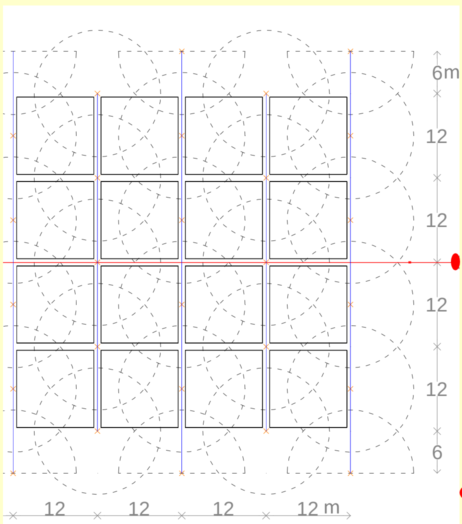
Property	0–23 cm	23–40 cm	40–70 cm	70–120 cm
pH (1:2.5)	8.16	8.06	8.02	7.84
EC† (1:2.5), dS m^{-1}	0.31	0.45	0.90	2.19
Organic C, g kg^{-1}	18.5	17.0	12.7	13.0
CO_3, g CO_3^{2-} kg^{-1}	198.0	201.3	159.0	181.0
Texture				
Sand, g kg^{-1}	260	250	250	250
Silt, g kg^{-1}	490	510	520	460
Clay, g kg^{-1}	250	240	230	290

† EC, Electrical conductivity.

Material and methods

AgSystems

Experimental design



-Sprinkle irrigation (12x12 m)

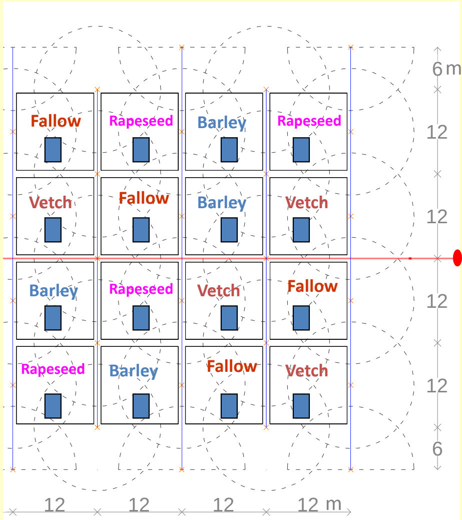
- Main crop: maize (cv G-98 Pioneer) cycle 700

- N fertilizer application (NH_4NO_3):
  V4: 140 kg N ha^{-1}
  V8: 70 kg N ha^{-1}

(mm)	2007	2008	2009
ETc	643.7	624.9	716.1
Irrigation	575.7	533.7	656.4
Rain	106.6	142.0	45.4
Total water input	682.3	675.7	701.8
Total water input/ETc	1.06	1.08	0.98

Material and methods

- **Experimental design**



- Factorial: 4 factors x 4 reps
- Factors: 3 cover crops
  fallow

Cover crop	Cultivar	Sowing rate
Barley *Hordeum vulgare L.*	Clarine	180 kg ha^{-1}
Vetch *Vicia villosa* L.	Vereda	140 kg ha^{-1}
Rapeseed *Brassica napus L.*	Licapo	6 kg ha^{-1}

Maize: April ⟹ October

Cover crops: October ⟹ March

N^{15} Microplots (2 x 1.25 m^2)

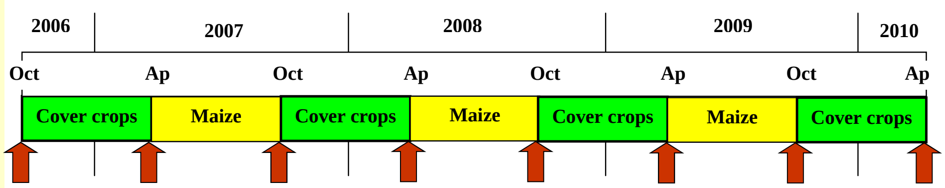
Labeled $^{15}NH_4{}^{15}NO_3$ (2.5 atom % ^{15}N)


SEMEATO

Material and methods

AgSystems

- Experimental procedure and measurements



Soil $NMIN_{1.2\ m}$: KCl extracts in 0.20 m intervals (NH_4^++NO_3^-)

Plant biomass CC: aerial 4 x 1 m^2 per plot; roots in soil cores down to 0.4 m

Maize yield and biomass: central fringe of 14 m^2 per plot (10 x 1.4 m^2)

Plant N and C concentration: dry combustion of plant components

^{15}N by mass spectrometry: plant and soil samples from microplots

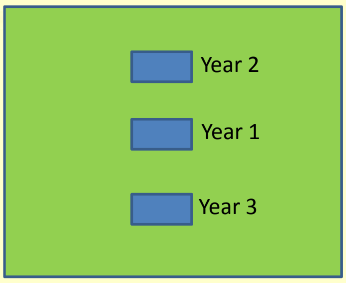
Crop N uptake $= \sum$ (Biomass x Plant N concentration)$_{components}$

Material and methods

AgSystems

N^{15} Microplots (2 x 1.25 m^2)
Labeled $^{15}NH_4{}^{15}NO_3$ (2.5 atom % ^{15}N)

Two applications: V4: 140 kg N ha^{-1}
V8: 70 kg N ha^{-1}



Crop ^{15}N recovery ($^{15}N_R$) $= N_{uptake} \dfrac{\{[^{15}N_{plant}] - [^{15}N_{nat.\ ab.}]\}}{\{[^{15}N_{fert}] - [^{15}N_{nat.\ ab.}]\}}$

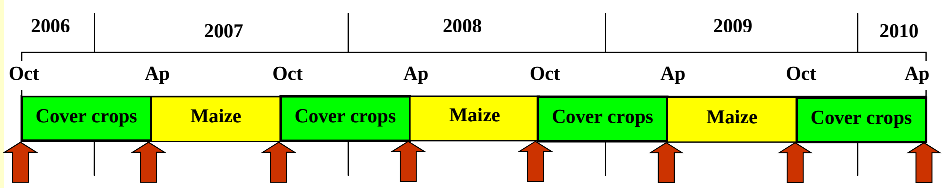
N fertilizer efficiency (NRF) = 100 $^{15}N_R$ / $^{15}N_{fert}$

N from other sources (NOS) = Crop $N_{uptake} - {}^{15}N_R$

Soil ^{15}N recovered $= N_{soil} \dfrac{\{[^{15}N_{soil}] - [^{15}N_{nat.\ ab.}]\}}{\{[^{15}N_{fert}] - [^{15}N_{nat.\ ab.}]\}}$

Material and methods

- Experimental procedure and measurements



Soil $NMIN_{1.2\ m}$: KCl extracts in 0.20 m intervals (NH_4^++NO_3^-)

Plant biomass cover crops: 1 m^2 per plot (4 x 0.25 m^2)

Maize yield: central fringe of 14 m^2 per plot (10 x 1.4 m^2)

Plant N and C concentration: dry combustion of plant components

^{15}N by mass spectrometry: plant and soil samples from microplots

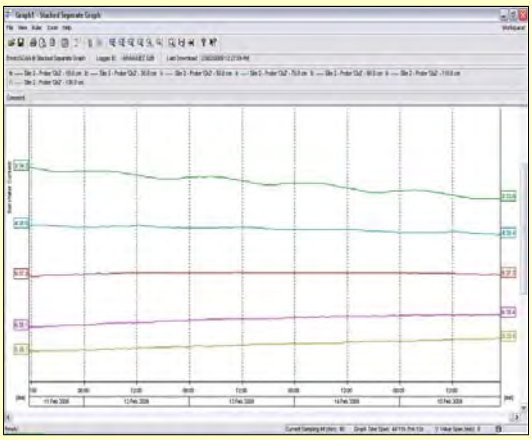
Soil water content ($SWC_{1.2\ m}$): FDR in 0.20 m intervals

Soil solution in ceramic cups at 1.2 m: determination of [NO_3^-]

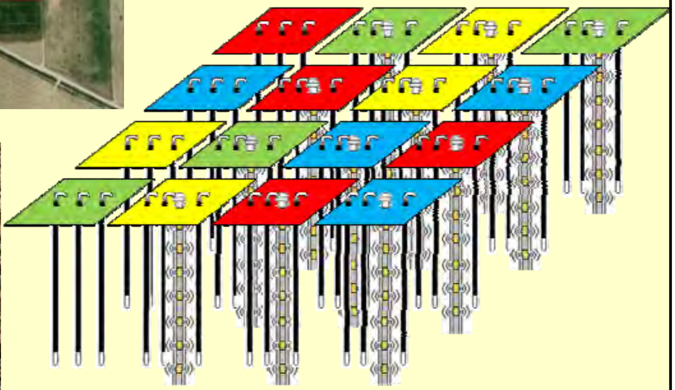
Material and methods

Soil water content

-12 access tubes for FDR sensors (EnviroSCAN®)
-Sensors at 10, 30, 50, 70, 90, 110 y 130 cm
-Sensors previously calibrated in this soil (Gabriel et al., 2010)
-Readings every hour



Material and methods



Material and methods

Calculations

-**Water balance :** obtained by inverse calibration of the numerical model WAVE (Vanclooster et al. 1996) with soil water data collected daily with FDR sensors.

Outputs: Crop evapotranspiration (ETc)

Water percolation below root zone (= Drainage)

Runoff (negligible)

- **Nitrate leaching:**

soil solution sampling intervals: $N\text{-}NO_3^-$ leached = Drainage x $[N\text{-}NO_3^-]_{soil\ solution\ 1.3\ m}$

Cumulative nitrate leaching = Σ (nitrate leaching intervals)

Material and methods

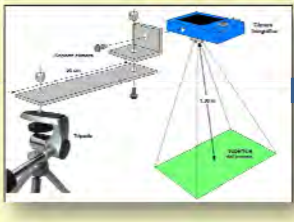
AgSystems

Direct estimation of crop parameters: Kc, LAI, effective rooting depth

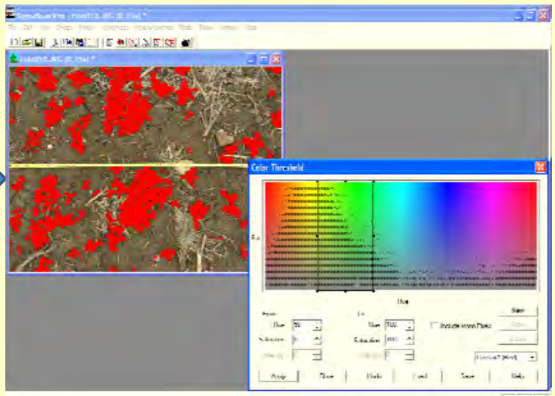
Monitoring of ground cover (GC) base on digital image analysis

GC → **Kc** FAO method (Allen et al., 1998)

GC → **LAI** estimated by (Ramírez et al., 2012)



- Four images of 1 m^2 per plot
- Every other week

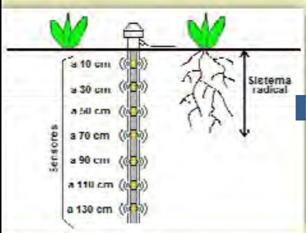


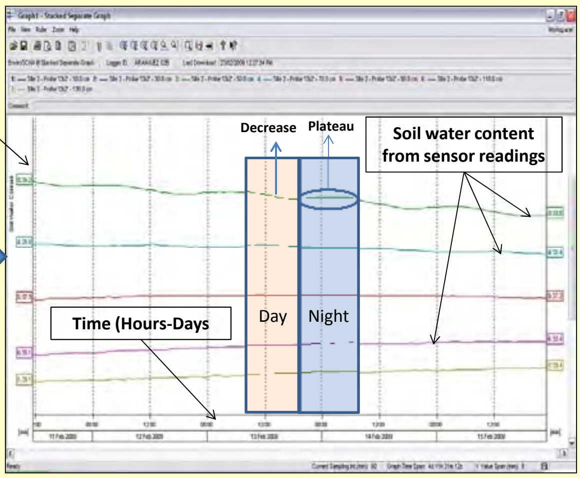
Material and methods

AgSystems

Direct estimation of crop parameters: Kc, LAI, effective rooting depth

Effective rooting depth





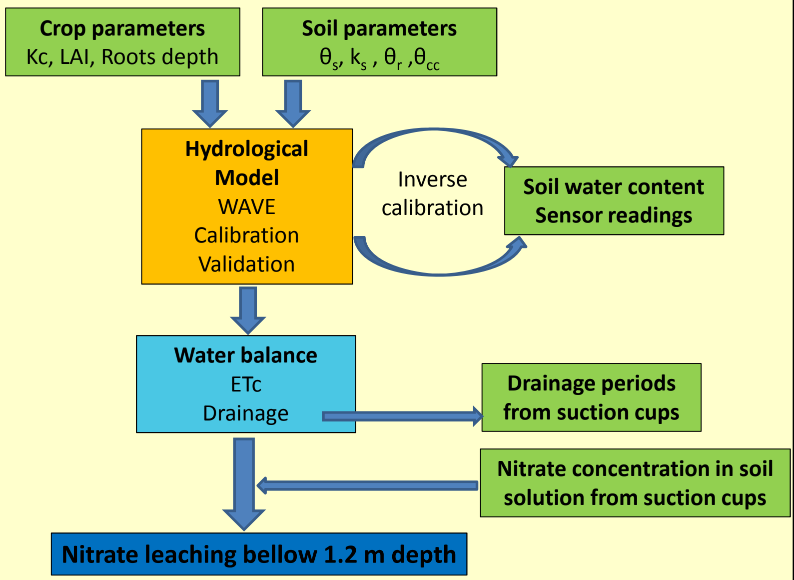
Material and methods

Direct estimation of soil parameters

- Bulk density (estimation of soil saturation water content θ_s)
- Hydraulic conductivity (k_s) in disturbed soil samples
- Residual soil water content (θ_r) from sensor readings
- Soil water content at field capacity (θ_{cc}) from sensor readings

Material and methods

Water balance



Results

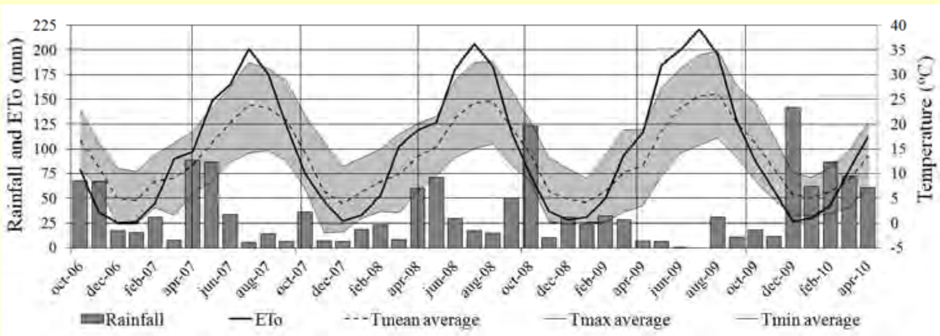
-crop productivity and N uptake by CC and maize

- N fertilizer efficiency and recovery

- accumulation of soil mineral N

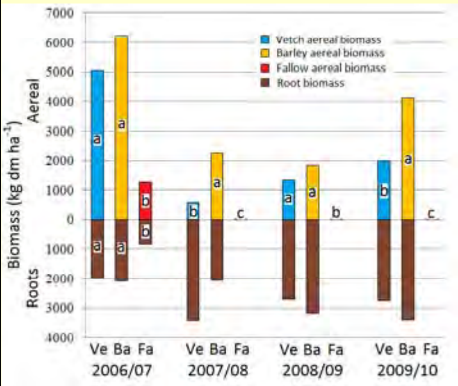
Results

Climate data at the field trial during the experimental period

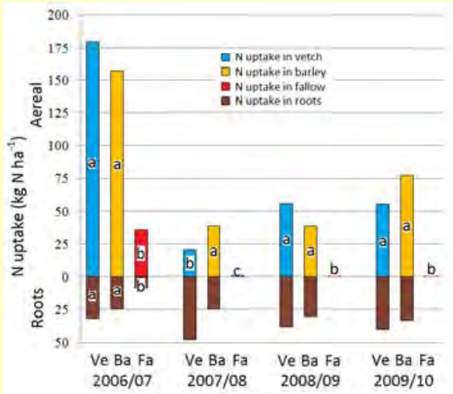


Results

Cover crops biomass



Cover crops N content



Vetch N_2 fixed: 13.9 68 % | 17.9 32 % | 20.8 kg N/ha 45 %

Results

Maize biomass, yield and N content as affected by cover crops

		Biomass (kg ms ha^{-1})		N Concentration (%)		N Content (kg N ha^{-1})		
Year	Treatment	Grain	Above ground	Grain	Above ground	Grain	Biomass	Above ground
2007	Vetch	12546	24129	1.16	0.49	168.7	44.8	213.5
	Barley	12922	25243	1.20	0.40	179.0	40.1	219.1
	Fallow	12351	24646	1.22	0.48	175.1	47.8	222.9
2008	Vetch	11590	22195	1.36	0.66	157.3	66.3	223.6
	Barley	11708	21805	1.30	0.61	151.4	58.2	209.6
	Fallow	11438	22281	1.30	0.61	147.3	61.4	208.8
2009	Vetch	11831	22477	1.35	0.72	158.7 **a**	71.2	230.0 **a**
	Barley	9796	18792	1.35	0.75	129.0 **ab**	63.2	192.2 **ab**
	Fallow	8446	17115	1.35	0.8	110.3 **b**	62.2	172.5 **b**

Results

15N recovered from fertilizer by maize and NOS

Year	Treatment	^{15}N Concentration (%) Grain		Biomass		^{15}N Recovery (kg N ha^{-1}) Grain	Biomass	Total	NRF (%)	NOS (kg N ha^{-1})	
2007	Vetch	1.10		1.07		66.9	17.2	84.1	40.0	129.4	
	Barley	1.18		1.18		79.2	17.7	97.0	46.2	122.1	
	Fallow	1.13		1.10		77.8	20.9	98.7	47.0	124.2	
2008	Vetch	1.17	b	1.19	b	69.1	29.8	99.0	47.1	124.6	a
	Barley	1.27	a	1.29	a	77.0	30.6	107.6	51.2	102.0	b
	Fallow	1.29	a	1.29	a	73.7	30.4	104.1	49.6	104.7	b
2009	Vetch	1.16	b	1.19	b	68.2	31.9	100.1	47.7	129.9	a
	Barley	1.29	a	1.33	a	62.4	31.5	93.9	44.7	98.3	b
	Fallow	1.23	ab	1.29	a	53.5	31.2	84.8	40.4	87.7	b

Results

15N recovered in the soil after maize h crops

^{15}N recovered in cover crops biomass

Treatment	^{15}N recovered (kg N ha^{-1})
Vetch	0.1
Barley	0.8
Bare fallow	–
Vetch	2.9b
Barley	13.7a
Bare fallow	0.0b
Vetch	0.7b
Barley	6.2a
Bare fallow	0.1b

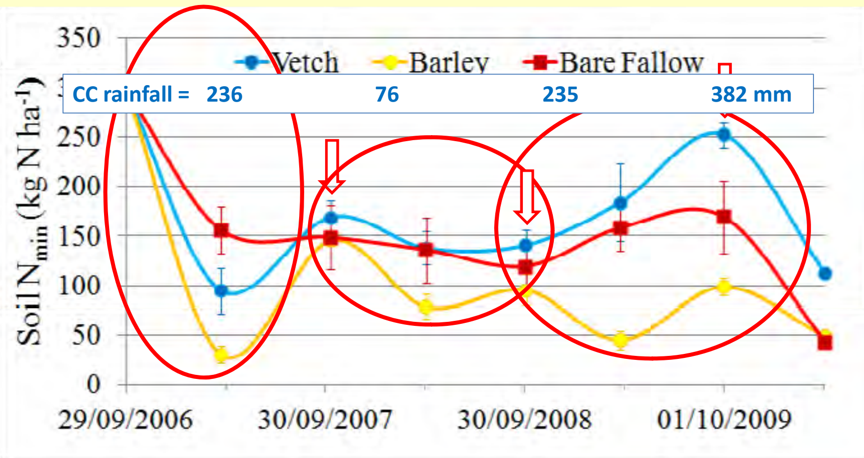
After maize / **After cover crops**

Treatment	2007	2008	2009	2007/08	2008/09	2009/10
	kg N ha^{-1}					
Vetch 0–40 cm	64.24	90.57a	88.17	29.28	40.70	72.07a
Barley 0–40 cm	54.03	46.94b	87.02	29.99	40.02	54.08b
Bare fallow 0–40 cm	52.06	54.85b	80.61	29.25	44.66	54.86b
Vetch 40–80 cm	9.63	12.29	17.26	2.64	17.50	7.80
Barley 40–80 cm	3.96	5.75	16.43	1.93	5.07	10.16
Bare fallow 40–80 cm	5.89	9.34	14.85	4.66	10.66	6.77
Vetch 80–120 cm	2.18	1.34	3.97	1.59	7.54	7.40
Barley 80–120 cm	3.79	3.23	5.30	0.35	2.44	2.55
Bare fallow 80–120 cm	4.89	5.55	9.37	3.18	5.93	5.96
Vetch 0–120 cm	76.05	104.20a	109.40	33.51	65.74a	87.27a
Barley 0–120 cm	61.78	55.92b	108.75	32.27	47.53b	66.79b
Bare fallow 0–120 cm	62.84	69.74ab	104.83	37.09	61.25ab	67.59b
Treatment	NS	*	NS	NS	NS	NS
Depth	*	*	*	*	*	*

Within measuring date and depth, treatments followed by different letter are significantly different at $P<0.05$ by Duncan's test.
* Significant at the 0.05 probability level, or NS not significant in the ANOVA over treatments and depth.

Results

NMIN in the upper 1.2 m of soil as affected by cover crops



Results

-crop productivity and N uptake by CC and maize

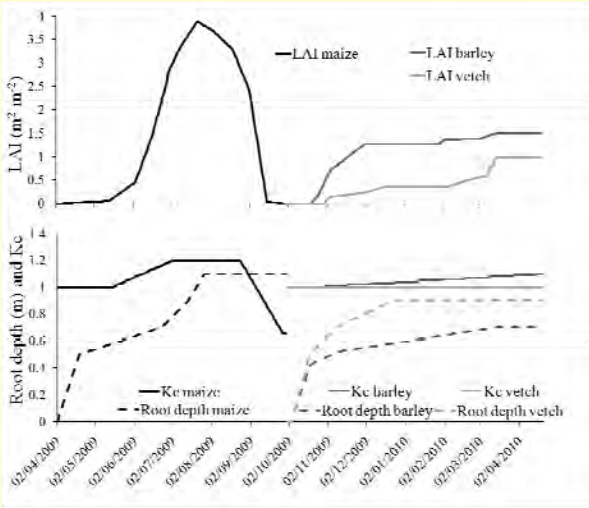
- N fertilizer efficiency and recovery

- accumulation of soil mineral nitrogen

- **water balance and nitrate leaching**

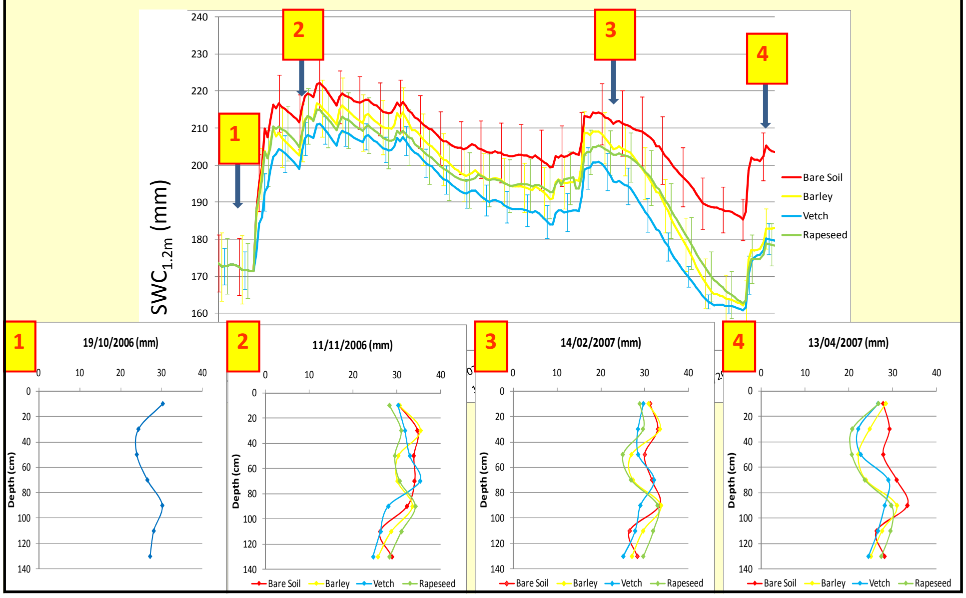
Results

Crop parameters evolution: LAI, Kc and effective rooting depth

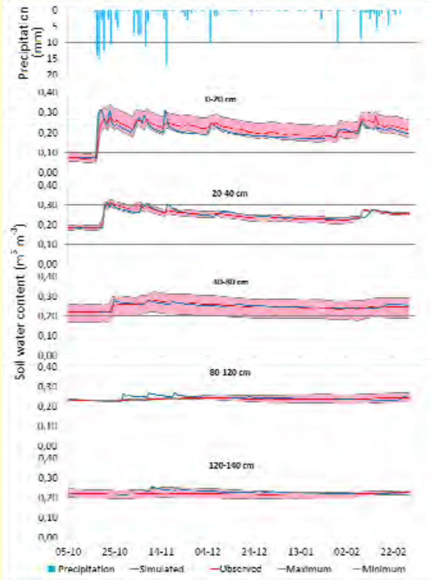


Results

Soil water content Cover crops period 2006-2007

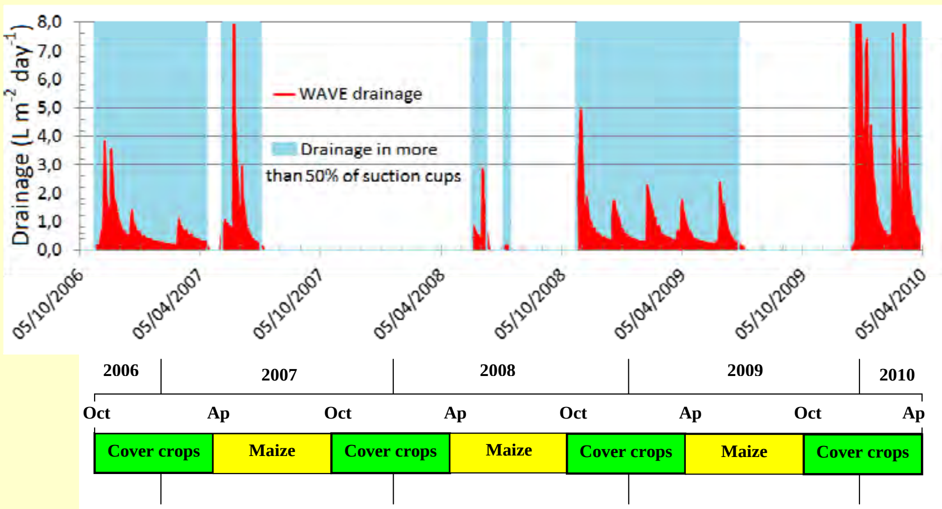


Validation WAVE model (C_{ef} = 0.89; RMSE = 6.7 mm)

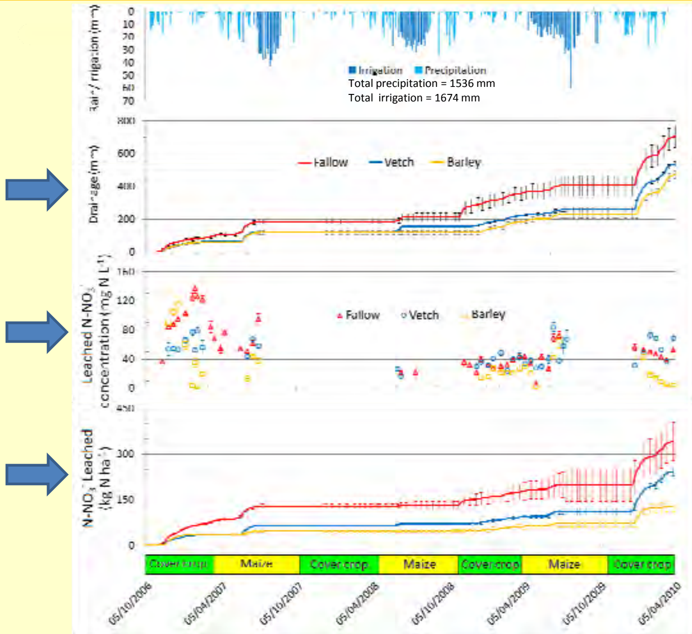


Results

Drainage periods simulated ~ Drainage periods based on suction cups soil solution present > 50%



Results: Drainage and nitrate leaching



Conclusiones

• Reemplazar el barbecho por cultivos cubierta durante el periodo intercultivo del maíz en un sistema intensivo de regadío redujo la lixiviación de nitratos sin reducir la producción de maíz. En las parcelas con veza, se observó un aumento de la disponibilidad de N tras el segundo año.

• El NRF no se vio afectado por los CC y fue de 46% de media. Sin embargo, en los tratamientos con CC las pérdidas de N fueron menores en los años lluviosos, en los que el N fue retenido en el suelo. El contenido de ^{15}N del suelo fue mayor en la veza, sugiriendo que fue retenido en fracciones más estables del horizonte superficial.

• EL mayor efecto de los CC en el control de la lixiviación de nitratos apareció durante el período intercultivo los años húmedos. Los años secos, cuando el nitrato se acumula en el suelo durante el invierno, el papel de los CC controlando la lixiviación de nitratos fue también relevante durante los estadios iniciales del maíz.

• Los CC aumentaron el reciclaje de N en el sistema y la disponibilidad de N el horizonte superficial. La cebada fue más eficiente controlando la lixiviación de nitratos. La veza favoreció la retención y disponibilidad de N en horizontes superficiales, reduciendo la lixiviación de nitratos respecto al barbecho.

European Journal of Agronomy. 2011. 34: 133-143
Agriculture Ecosystems & Environment. 2012. In press

Índice presentación

- Empleo de cultivos cubierta en sistemas de regadío
- Proyecto NTOOLBOX:
  - Catálogo de estrategias para control de la lixiviación de nitratos
  - NDICEA: Modelo de simulación del balance de N en sistemas de cultivo

Toolbox of cost-effective strategies for on-farm reductions in N losses to water (N-Toolbox)

Objetivo general

Desarrollo de un conjunto de herramientas tecnológicas que faciliten la implementación de las estrategias para reducir las pérdidas de nitrógeno al agua desde los sitemas agrarios.

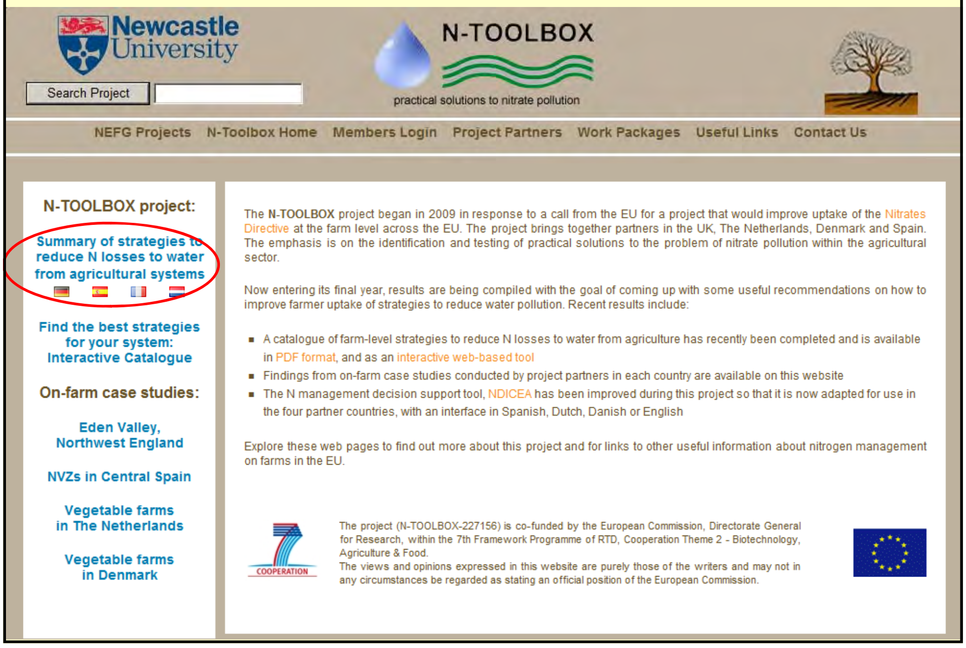
Participantes

Newcastle University (RU) Coordinador
Louis Bolk Institute- Wageningen University (Países Bajos)
University of Aarhus (Dinamarca)
Universidad Politécnica de Madrid

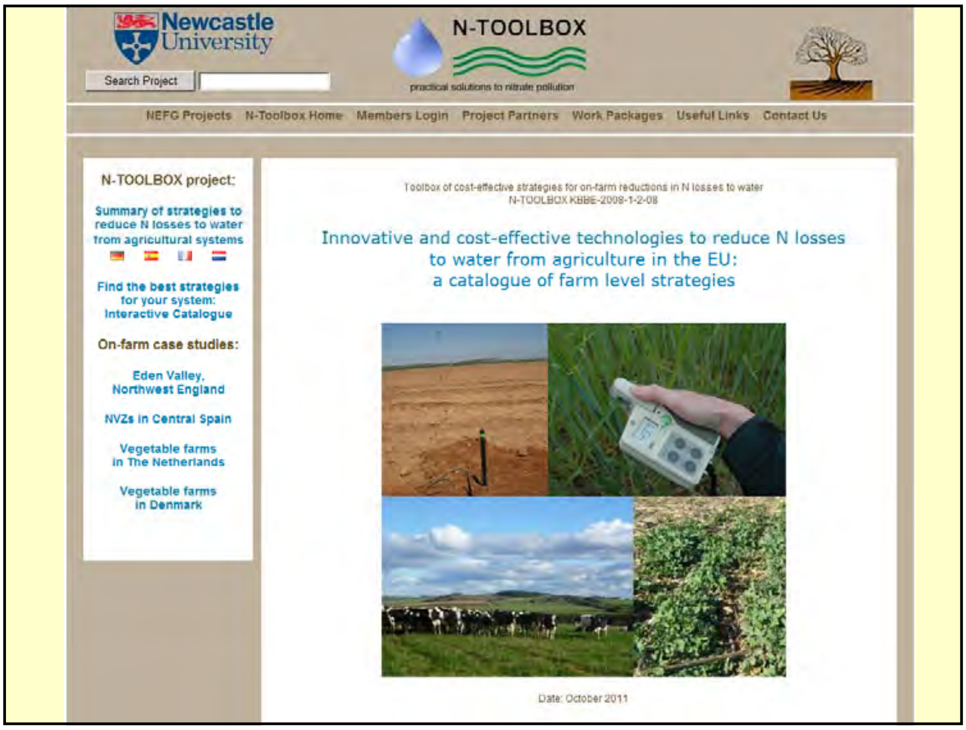
Sistemas agrarios

1. Granjas de producción de leche. Reino Unido.
2. Sistemas integrados de hortícolas y cereales. Dinamarca.
3. Sistemas de producción hortícola en suelos arenosos. Países Bajos.
4. Sistemas de regadío basados en producción de cereal. Zona centro de España.

http://research.ncl.ac.uk/nefg/ntoolbox/




Newcastle University
Search Project
N-TOOLBOX
practical solutions to nitrate pollution
NEFG Projects N-Toolbox Home Members Login Project Partners Work Packages Useful Links Contact Us
N-TOOLBOX project:
Summary of strategies to reduce N losses to water from agricultural systems
Find the best strategies for your system: Interactive Catalogue
On-farm case studies:
Eden Valley, Northwest England
NVZs in Central Spain
Vegetable farms in The Netherlands
Vegetable farms in Denmark
back to English version (volver a la versión en inglés)
Resumen de las estrategias para reducir las pérdidas de N al agua desde los sistemas agrarios
El proyecto NTOOLBOX se inicio en 2009, financiado por la Unión Europea, para identificar estrategias agrarias a nivel de finca que permitan reducir las pérdidas de N al agua. En el proyecto se han producido una serie de documentos que describen el estado de conocimiento científico y aplicado de la implementación de estrategias para reducir las pérdidas de N (NLRS, en sus siglas en inglés) a nivel de finca. Si explora esta WEB encontrará muchos de estos documentos en formato pdf o convertidos en páginas WEB. En esta página, proporcionamos un resumen de las estrategias identificadas.
Las NLRS han sido divididas en 8 categorías. Haga clic en el enlace resaltado para ampliar información sobre las estrategias identificadas para cada categoría:
1. Almacenaje y tratamiento de residuos orgánicos
2. Manejo de ganado
3. Manejo de pastos para reducir pérdidas de N
4. Aplicación de dosis ajustadas
5. Mejores prácticas de manejo (BMP) de residuos orgánicos en suelos
6. Estrategias para regadíos
7. Ciclo eficiente de N a nivel de campo
8. Manejo de la escorrentía, drenaje y aguas residuales
1. Almacenaje y tratamiento de residuos orgánicos
En cualquier explotación ganadera en la que los animales están estabulados durante un período (excluye sistemas extensivos basados en pastoreo) los residuos orgánicos necesitan ser recogidos y almacenados antes de ser aplicados en tierras de cultivo. Surgen problemas cuando la capacidad de almacenaje para los residuos es insuficiente y los granjeros se ven obligados a aplicar los residuos en épocas no adecuadas. Este problema es especialmente relevante en las regiones del norte en las que hay un riesgo de contaminación cuando se aplican estiércoles durante el invierno en terrenos helados y/o en los que no hay un crecimiento activo de los cultivos. Por esta razón, el aumento de la capacidad de almacenaje es recomendable. El compostaje de residuos o emplear camas de establo con alto contenido de C, como la paja, puede ayudar a conservar N favoreciendo la conversión de N disponible en formas más estables de N orgánico. El riesgo de contaminación de cursos de agua con la escorrentía de las pilas de estiércol puede ser reducido colocando las pilas en lugares alejados de cursos de agua o sistemas de drenaje. Cubrir las zonas de almacenaje de estiércoles reduce la escorrentía, reduciendo por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Toolbox of cost-effective strategies for on-farm reductions in N losses to water
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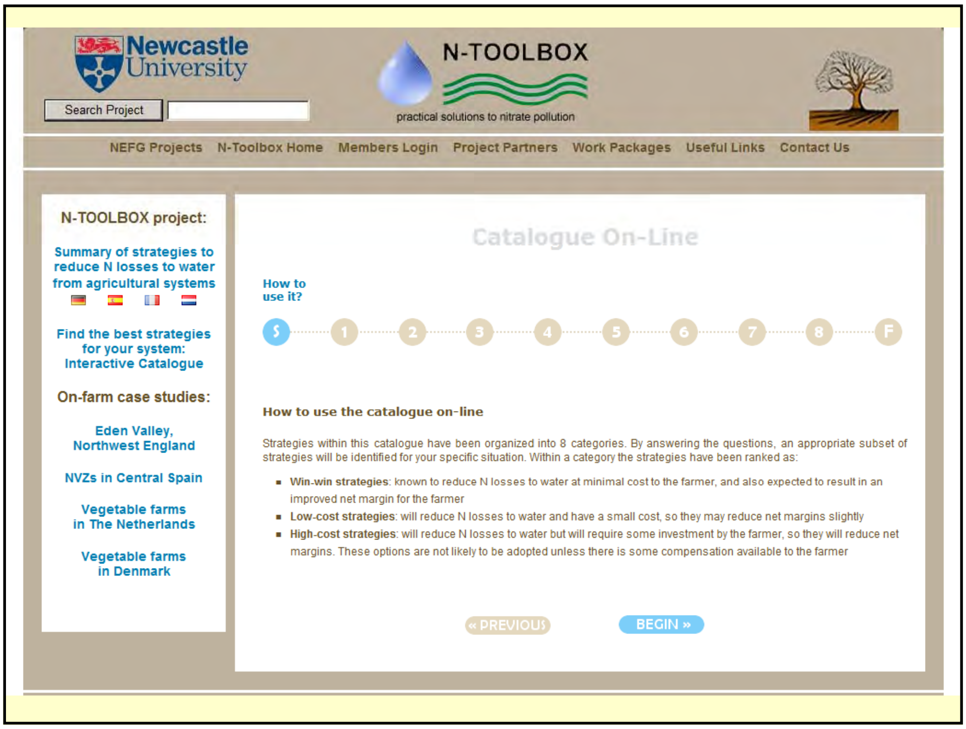
Innovative and cost-effective technologies to reduce N losses to water from agriculture in the EU: a catalogue of farm level strategies
Date: October 2011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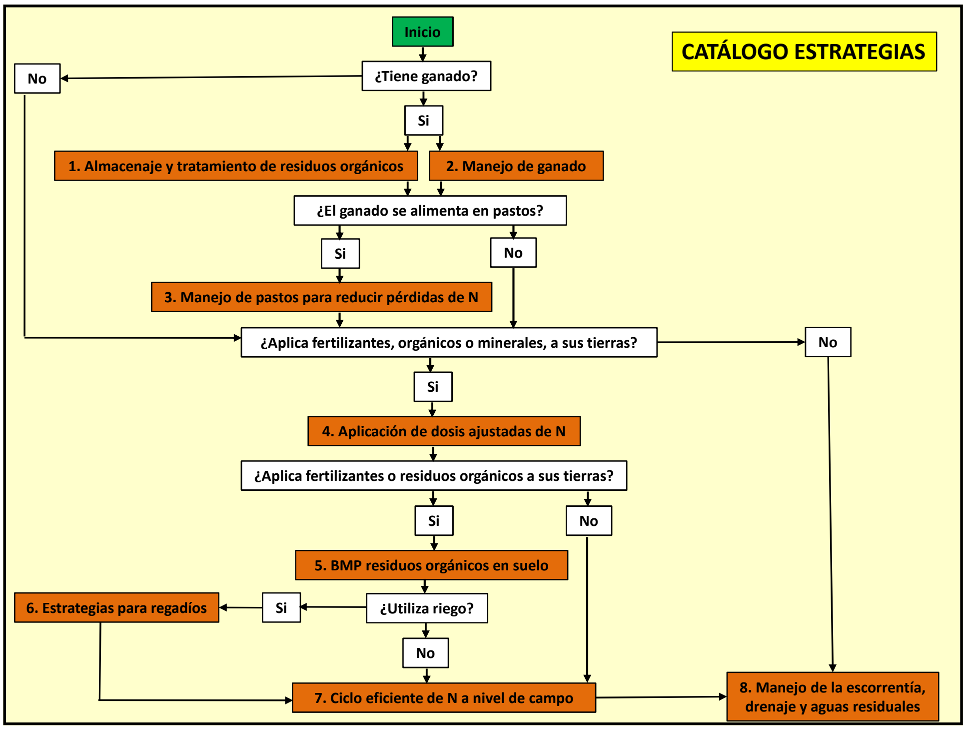
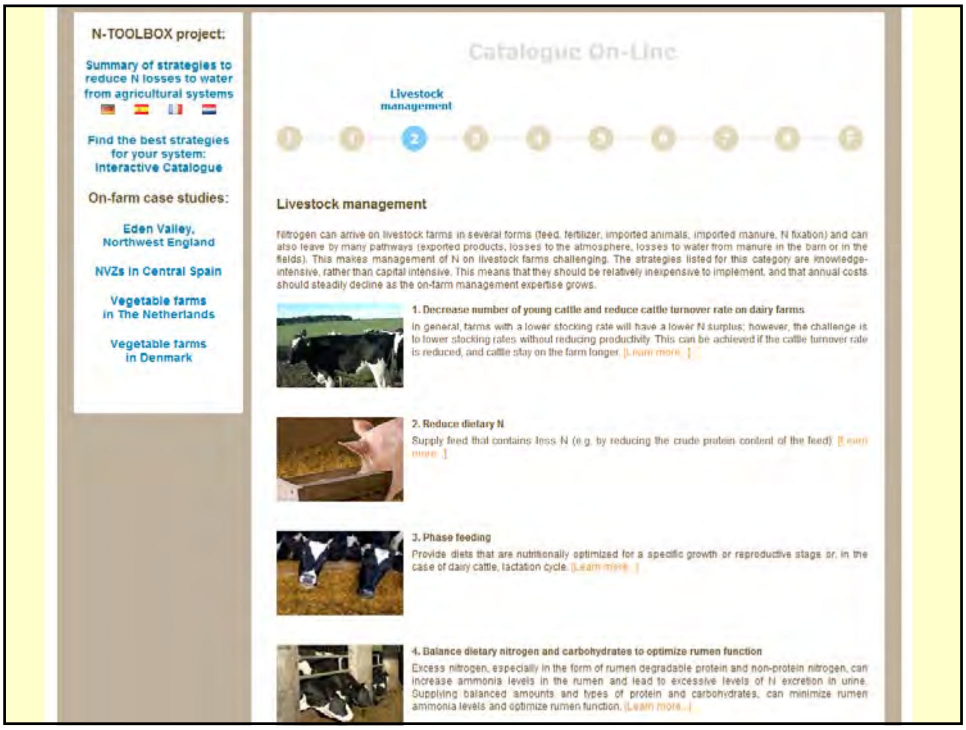
Catalogue On-Line
How to use it?
S 1 2 3 4 5 6 7 8 F
How to use the catalogue on-line
Strategies within this catalogue have been organized into 8 categories. By answering the questions, an appropriate subset of strategies will be identified for your specific situation. Within a category the strategies have been ranked as:
Win-win strategies: known to reduce N losses to water at minimal cost to the farmer, and also expected to result in an improved net margin for the farmer
Low-cost strategies: will reduce N losses to water and have a small cost, so they may reduce net margins slightly
High-cost strategies: will reduce N losses to water but will require some investment by the farmer, so they will reduce net margins. These options are not likely to be adopted unless there is some compensation available to the farmer
« PREVIOUS
BEGIN »


CATÁLOGO ESTRATEGIAS
Inicio
¿Tiene ganado?
No
Si
1. Almacenaje y tratamiento de residuos orgánicos
2. Manejo de ganado
¿El ganado se alimenta en pastos?
Si
No
3. Manejo de pastos para reducir pérdidas de N
¿Aplica fertilizantes, orgánicos o minerales, a sus tierras?
No
Si
4. Aplicación de dosis ajustadas de N
¿Aplica fertilizantes o residuos orgánicos a sus tierras?
Si
No
5. BMP residuos orgánicos en suelo
6. Estrategias para regadíos
Si
¿Utiliza riego?
No
7. Ciclo eficiente de N a nivel de campo
8. Manejo de la escorrentía, drenaje y aguas residuales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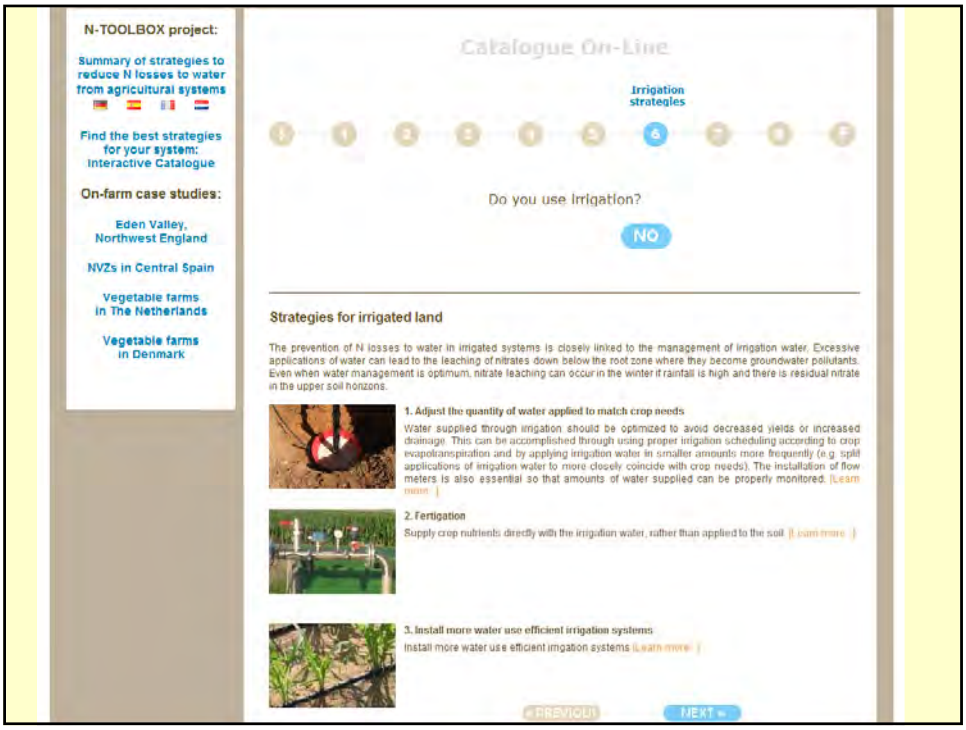
Livestock management
Livestock management
Nitrogen can arrive on livestock farms in several forms (feed, fertilizer, imported animals, imported manure, N fixation) and can also leave by many pathways (exported products, losses to the atmosphere, losses to water from manure in the barn or in the fields). This makes management of N on livestock farms challenging. The strategies listed for this category are knowledge-intensive, rather than capital intensive. This means that they should be relatively inexpensive to implement, and that annual costs should steadily decline as the on-farm management expertise grows.
1. Decrease number of young cattle and reduce cattle turnover rate on dairy farms
In general, farms with a lower stocking rate will have a lower N surplus; however, the challenge is to lower stocking rates without reducing productivity. This can be achieved if the cattle turnover rate is reduced, and cattle stay on the farm longer. [Learn more...]
2. Reduce dietary N
Supply feed that contains less N (e.g. by reducing the crude protein content of the feed). [Learn more...]
3. Phase feeding
Provide diets that are nutritionally optimized for a specific growth or reproductive stage or, in the case of dairy cattle, lactation cycle. [Learn more...]
4. Balance dietary nitrogen and carbohydrates to optimize rumen function
Excess nitrogen, especially in the form of rumen degradable protein and non-protein nitrogen, can increase ammonia levels in the rumen and lead to excessive levels of N excretion in urine. Supplying balanced amounts and types of protein and carbohydrates, can minimize rumen ammonia levels and optimize rumen function. [Learn more...]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Irrigation strategies
Do you use Irrigation?
NO
Strategies for irrigated land
The prevention of N losses to water in irrigated systems is closely linked to the management of irrigation water. Excessive applications of water can lead to the leaching of nitrates down below the root zone where they become groundwater pollutants. Even when water management is optimum, nitrate leaching can occur in the winter if rainfall is high and there is residual nitrate in the upper soil horizons.
1. Adjust the quantity of water applied to match crop needs
Water supplied through irrigation should be optimized to avoid decreased yields or increased drainage. This can be accomplished through using proper irrigation scheduling according to crop evapotranspiration and by applying irrigation water in smaller amounts more frequently (e.g. split applications of irrigation water to more closely coincide with crop needs). The installation of flow meters is also essential so that amounts of water supplied can be properly monitored. [Learn more...]
2. Fertigation
Supply crop nutrients directly with the irrigation water, rather than applied to the soil. [Learn more...]
3. Install more water use efficient irrigation systems
Install more water use efficient irrigation systems [Learn more...]
« PREVIOUS
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Efficient N cycling

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Efficient N cycling at the field level

Closely linked to balanced N application rates are strategies to ensure the most efficient use and cycling of N in the field. Even when N applications have been calculated to closely match crop needs, there is still some risk of N losses to water after the fertilizer or manure-N has been applied in the field.

1. Split fertilizer / manure applications

The required amount of fertilizer/manure is applied in several doses to more closely coincide with periods of crop demand. [Learn more...]

2. Cultivate land for crop establishment in spring rather than autumn

In arable systems: Cultivate arable land for spring crops in the spring instead of in the autumn.

In ley/grassland systems: Plough out the grassland in the spring instead of in the autumn.

[Learn more...]

3. Use a catch crop

Catch crops are cover crops grown to catch available N in the soil and thereby prevent N leaching losses. They are usually planted after harvest of the main, commercial crop and left to grow during the non-growing season instead of leaving the land fallow. [Learn more...]

4. Incorporation of high C:N ratio residues to promote immobilization of mineral N

Straw or other high C:N ratio residues are incorporated into the soil after crop harvest to act as a "sponge" that holds inorganic N in the soil during the season when no crop growth is occurring. [Learn more...]

3. Use a catch crop

Catch crops are cover crops grown to catch available N in the soil and thereby prevent N leach
crop and left to grow during the non-growing season instead of leaving the land fallow.

hide this content

How it works

By covering the land with a growing crop, nitrogen can be taken up instead of being lost through leaching during rainfall events. The crop will not only take up nitrogen but also water, reducing the amount of drainage occurring and hence reducing the amount of potential N leaching. The cover crop increases the retention of surplus inorganic N left in the soil after harvest of the main crop as well as capturing N released through on-going mineralization. In this way it can potentially reduce overwinter N leaching.

Regions and systems of applicability

Applicable in regions where there is a high amount of rainfall during the non-growing season i.e. where the main drainage occurs during the non-growing season. Especially applicable in temperate regions with mild winters as this will entail a high winter N mineralization and a longer growing season. It is also applicable in regions where irrigation is used during the dry months of the year, as this can result in an accumulation of inorganic N that is susceptible to leaching during the winter.

Cost

This strategy will require more labour during the non-growing season, equipment and fuel for seedbed establishment, and seed costs, as well as increased management time hence there will be on-going costs.

We have estimated that net margins per hectare can be increased by up to 180 €/ha in irrigated maize systems in Spain, depending on the type of catch crop planted, when there is also a market for the harvested catch crop. If the catch crop is not harvested for sale, net margins will be lower and may at times result in a net loss, due to the added cost of seed and establishment.

Effectiveness

There have been numerous studies which have documented varying degrees of reductions in over-winter N leaching when catch crops are grown. This will depend on levels of residual N after crop harvest, over-winter temperatures and rainfall, and the growth and vigour of the catch crop. As an example we have estimated that in irrigated systems of maize production in Spain, nitrate leaching could be reduced by as much as 111 kg N/ha if a barley crop is grown during the winter months. Other studies have shown that winter cover crops can reduce nitrate leaching by 40-70% compared to bare fallow.

Other considerations

The incorporation of the catch crop may lead to a proportion of the captured N being lost due to rapid mineralization of green plant materials, especially if some time elapses between incorporation and planting of the following crop. It is important to time catch crop incorporation to occur as closely as possible to the planting of the subsequent crop.

N leaching may increase in the long term (after approximately 10 years) in systems which continuously use catch crops, if fertilizer N is not reduced or the crop rotation is not changed. Therefore, catch crops should always be used in conjunction with balanced N application rates i.e. using an optimum N rate that includes an accurate estimate of soil N supply.

In the short term, yields of crops grown after catch crops can potentially decrease, especially if a legume catch crop is relied on as the sole source of N for the subsequent crop. This problem is worse if the C:N ratio of the catch crop is relatively high, resulting in immobilization of soil mineral N. In the first years artificial fertilization might be needed; however, in the long-term catch crops may benefit subsequent crops through soil organic N accumulation.

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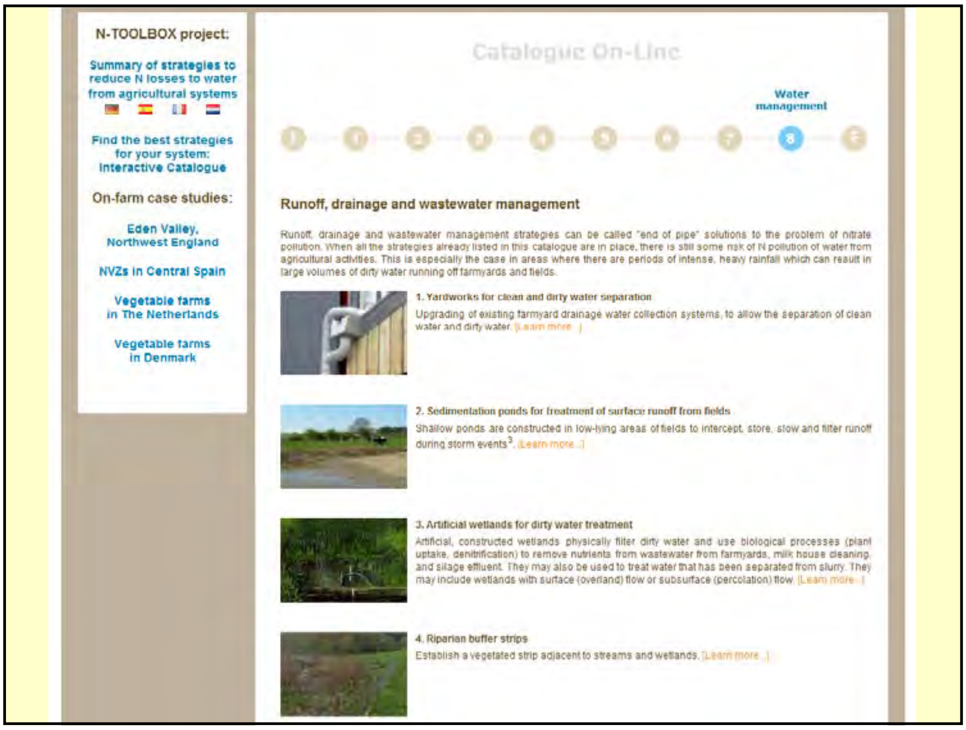
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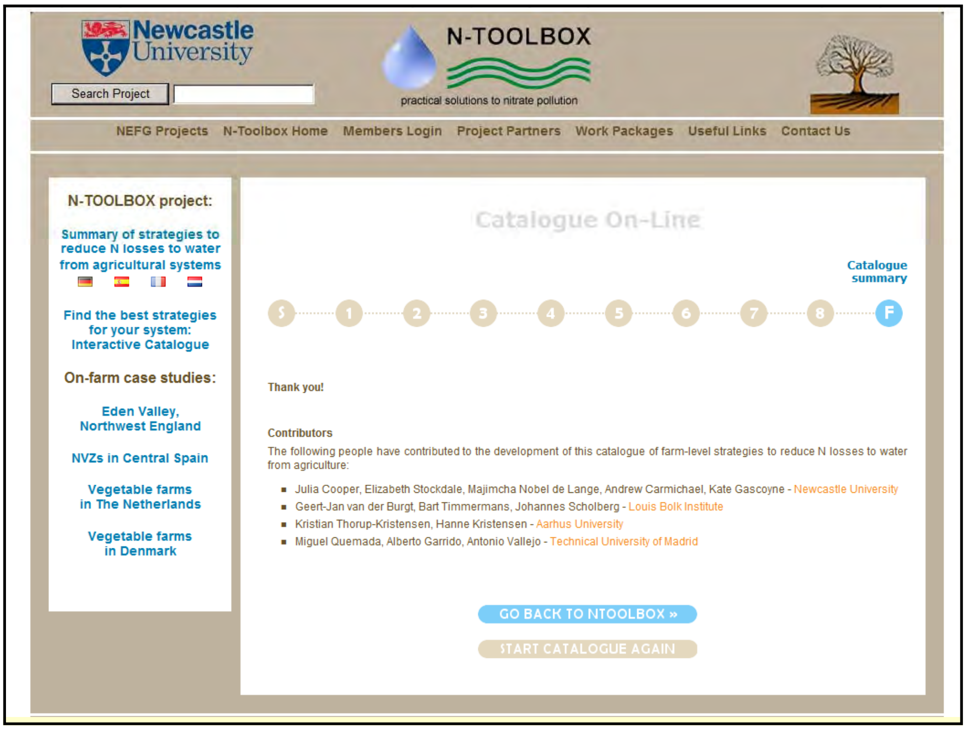
Water management
8
Runoff, drainage and wastewater management
Runoff, drainage and wastewater management strategies can be called "end of pipe" solutions to the problem of nitrate pollution. When all the strategies already listed in this catalogue are in place, there is still some risk of N pollution of water from agricultural activities. This is especially the case in areas where there are periods of intense, heavy rainfall which can result in large volumes of dirty water running off farmyards and fields.
1. Yardworks for clean and dirty water separation
Upgrading of existing farmyard drainage water collection systems, to allow the separation of clean water and dirty water. [Learn more...]
2. Sedimentation ponds for treatment of surface runoff from fields
Shallow ponds are constructed in low-lying areas of fields to intercept, store, slow and filter runoff during storm events3. [Learn more...]
3. Artificial wetlands for dirty water treatment
Artificial, constructed wetlands physically filter dirty water and use biological processes (plant uptake, denitrification) to remove nutrients from wastewater from farmyards, milk house cleaning, and silage effluent. They may also be used to treat water that has been separated from slurry. They may include wetlands with surface (overland) flow or subsurface (percolation) flow. [Learn more...]
4. Riparian buffer strips
Establish a vegetated strip adjacent to streams and wetlands. [Learn more...]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Catalogue summary
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Thank you!
Contributors
The following people have contributed to the development of this catalogue of farm-level strategies to reduce N losses to water from agriculture:
Julia Cooper, Elizabeth Stockdale, Majimcha Nobel de Lange, Andrew Carmichael, Kate Gascoyne - Newcastle University
Geert-Jan van der Burgt, Bart Timmermans, Johannes Scholberg - Louis Bolk Institute
Kristian Thorup-Kristensen, Hanne Kristensen - Aarhus University
Miguel Quemada, Alberto Garrido, Antonio Vallejo - Technical University of Madrid
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- Proyecto NTOOLBOX:
  - Catálogo de estrategias para control de la lixiviación de nitratos
  - NDICEA: Modelo de simulación del balance de N en sistemas de cultivo

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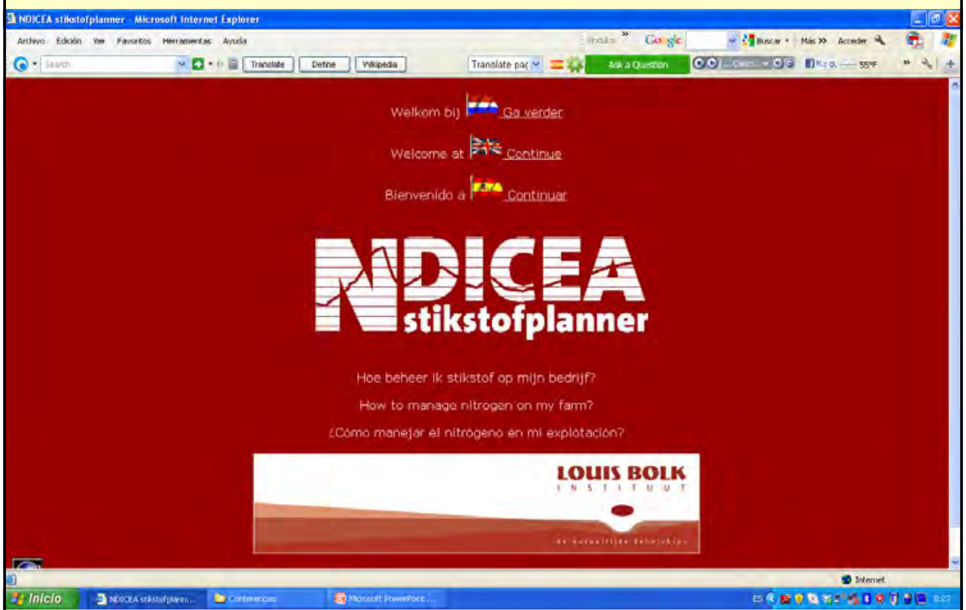

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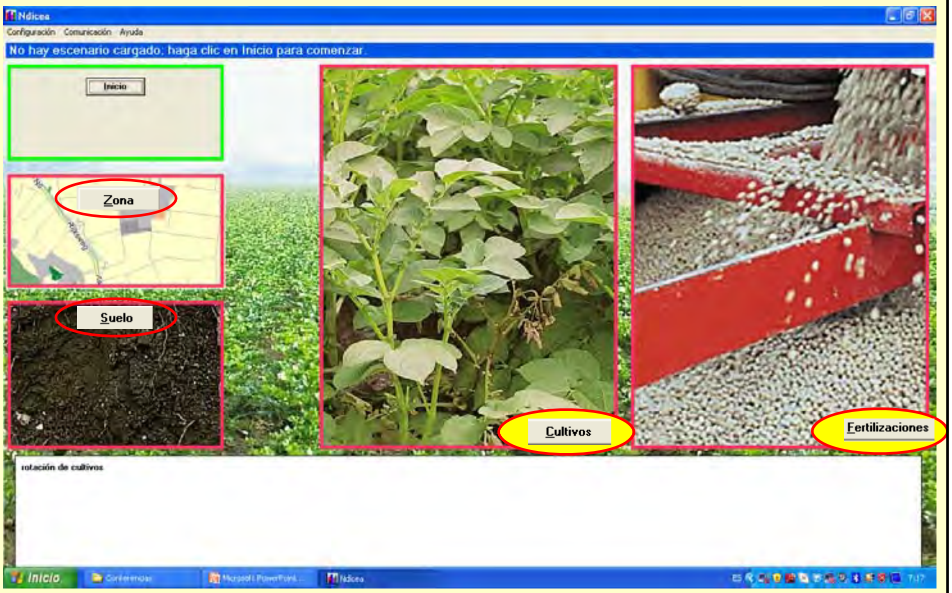
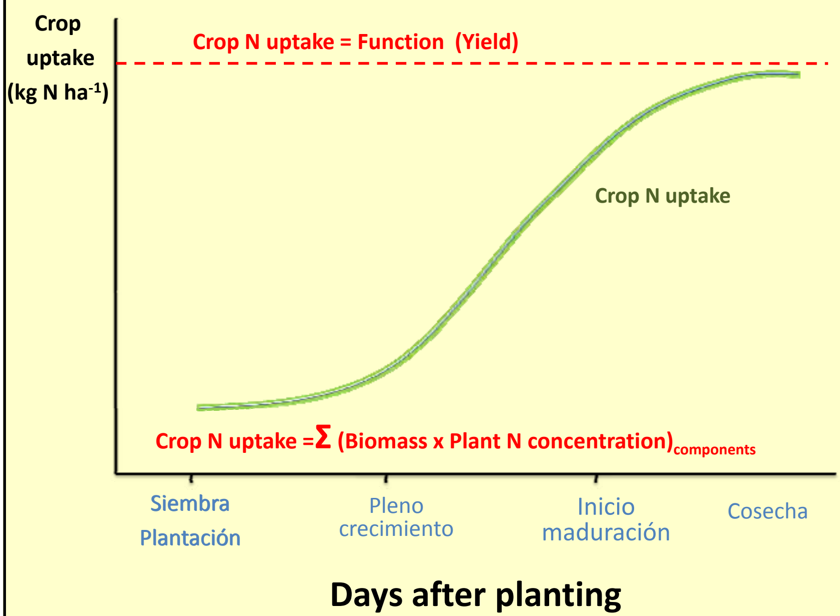
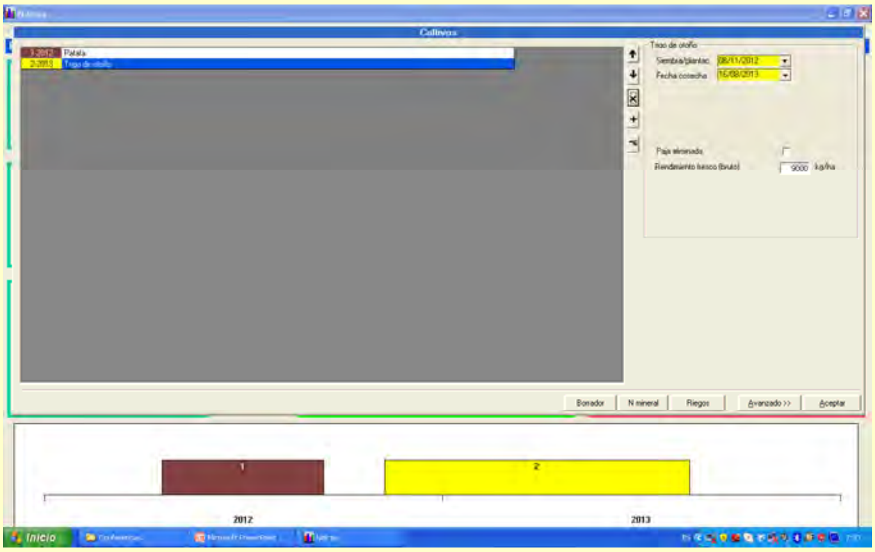


Cultivos: targeted oriented



NDICEA: cultivo



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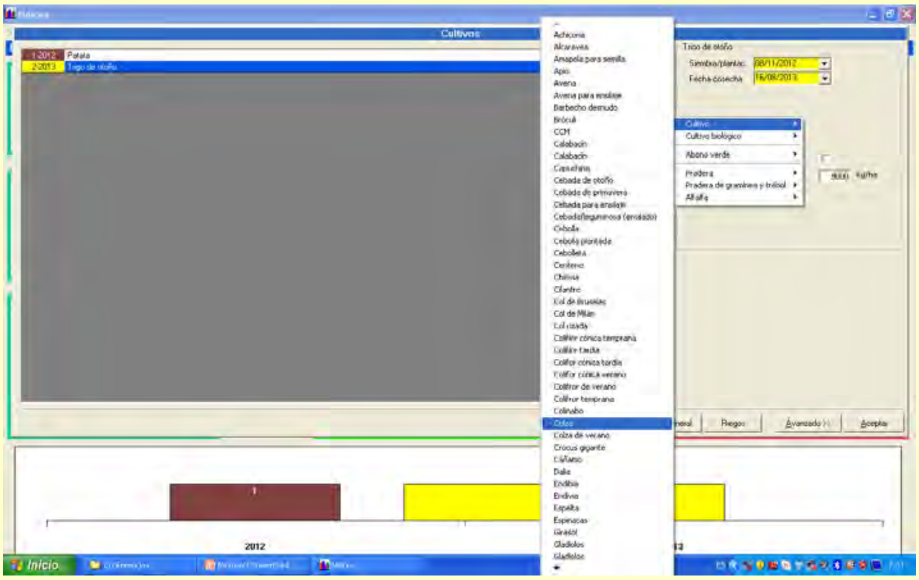

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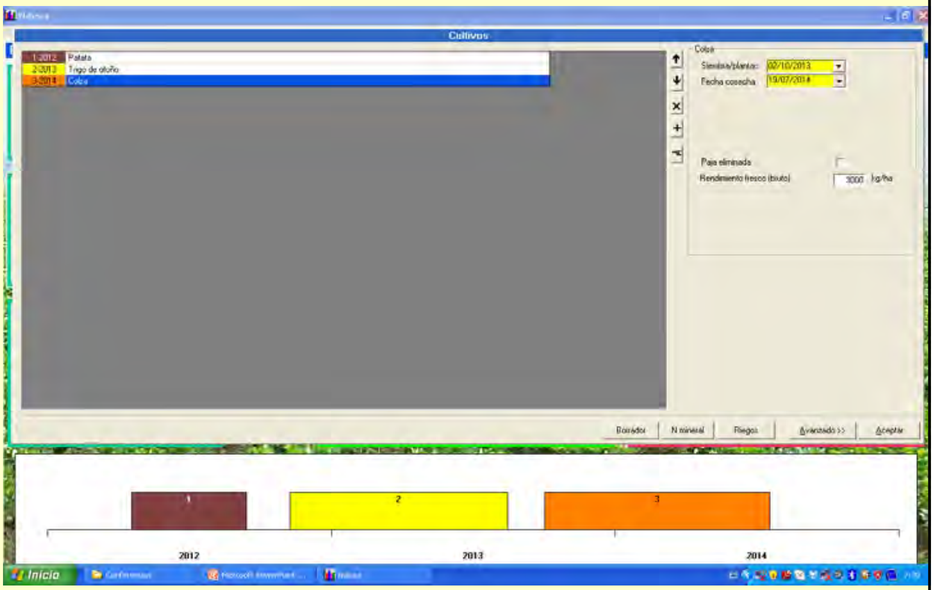

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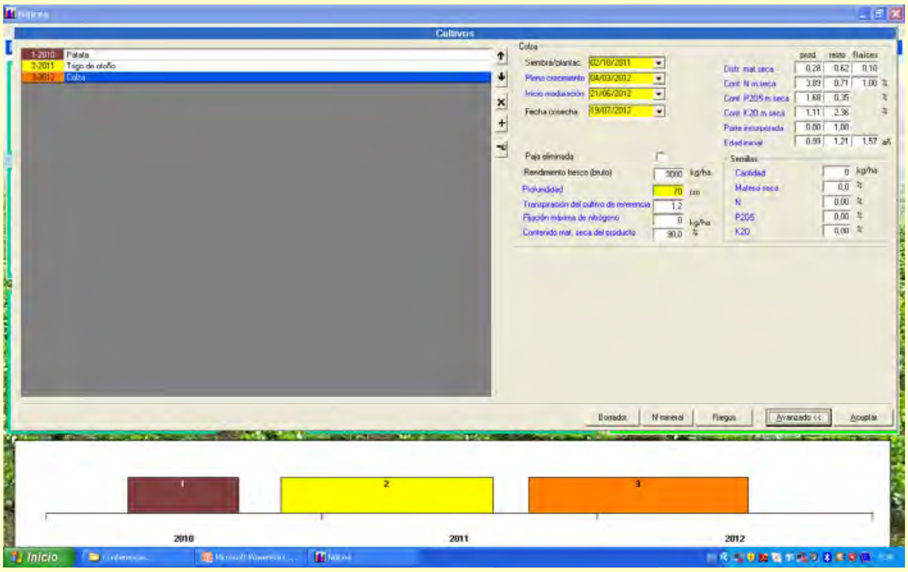
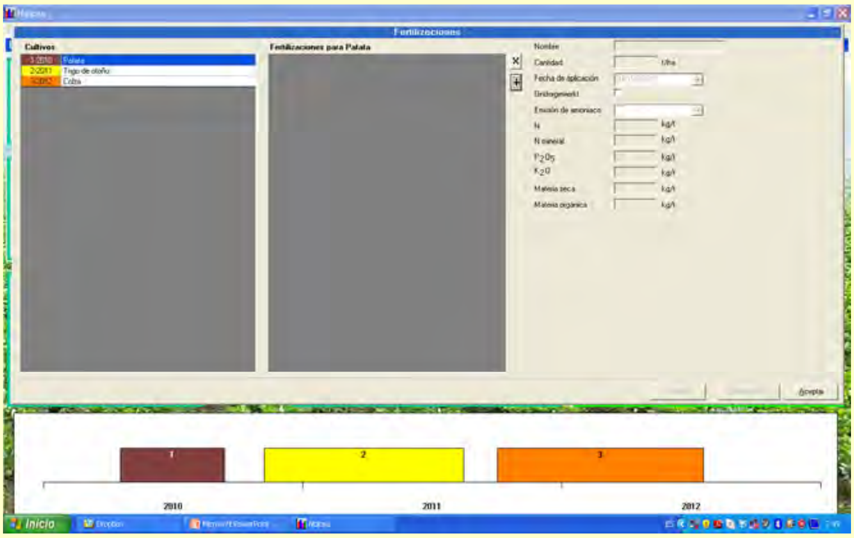
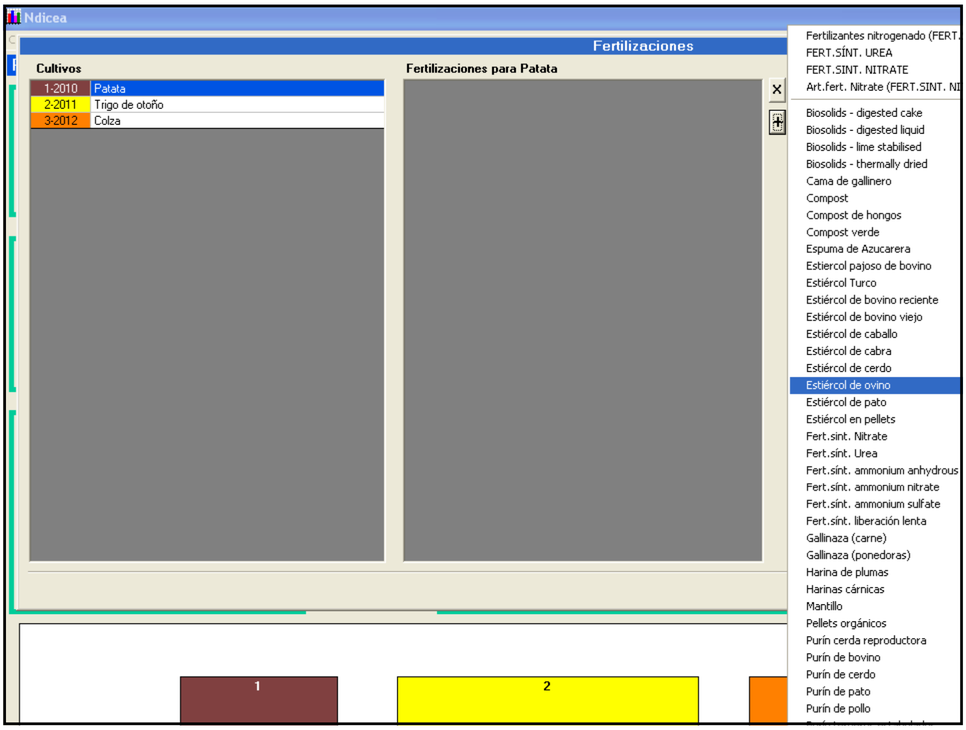
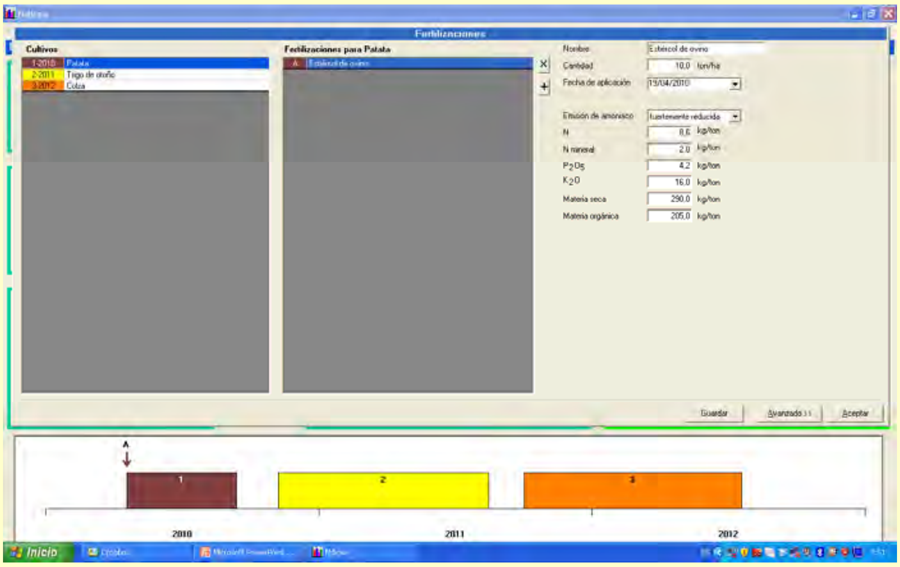


NDICEA: fertilización

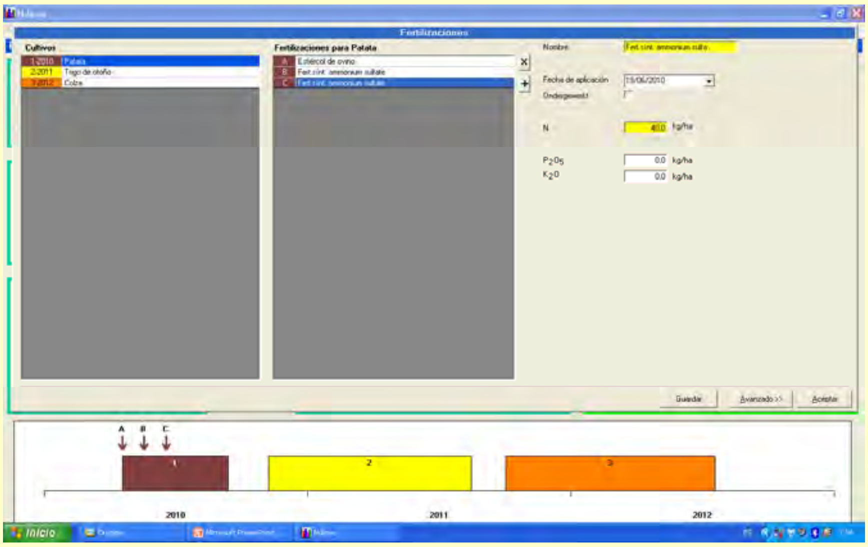




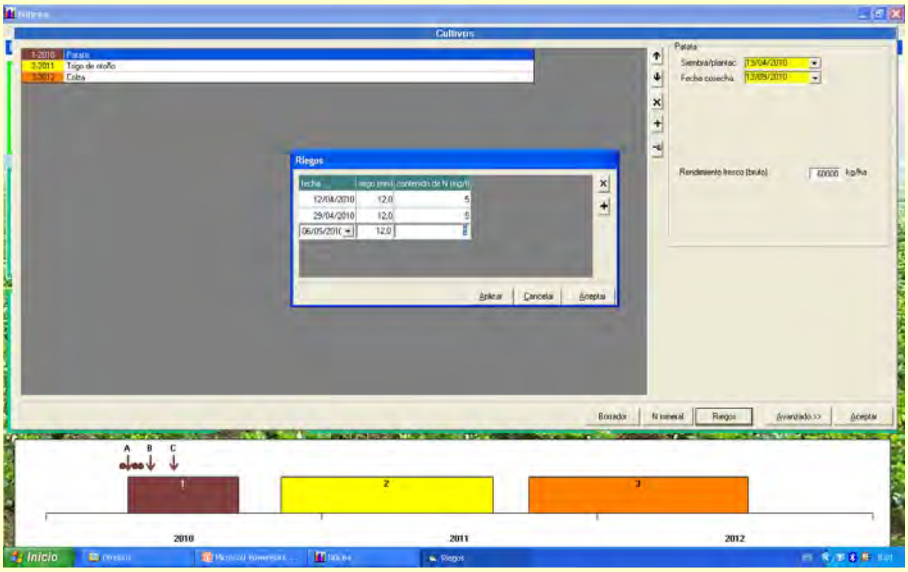
NDICEA: fertilizantes



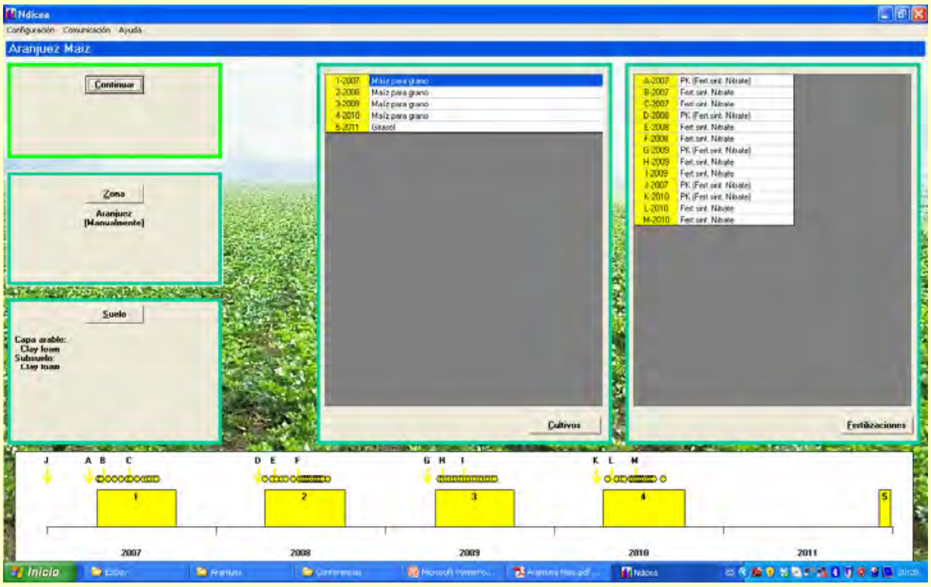
NDICEA: fertilizantes



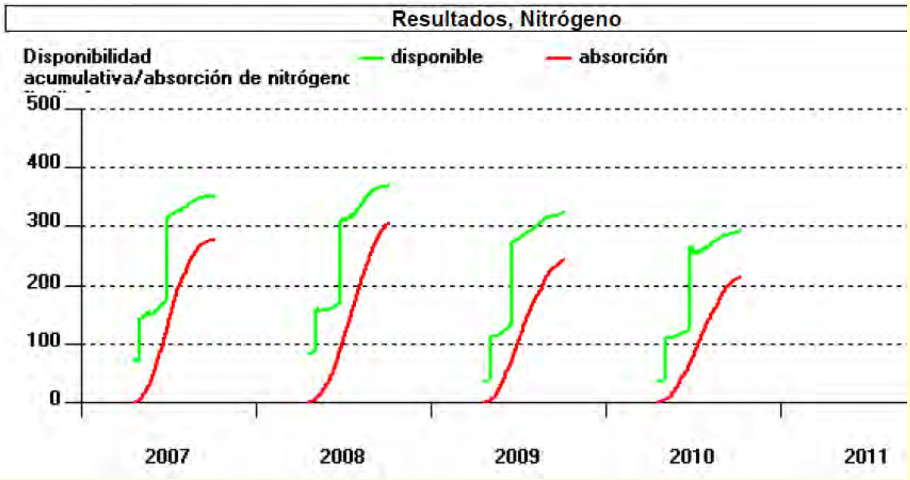
NDICEA: riegos



NDICEA: Aranjuez Maíz-Barbecho



NDICEA: Aranjuez
Maíz-Barbecho

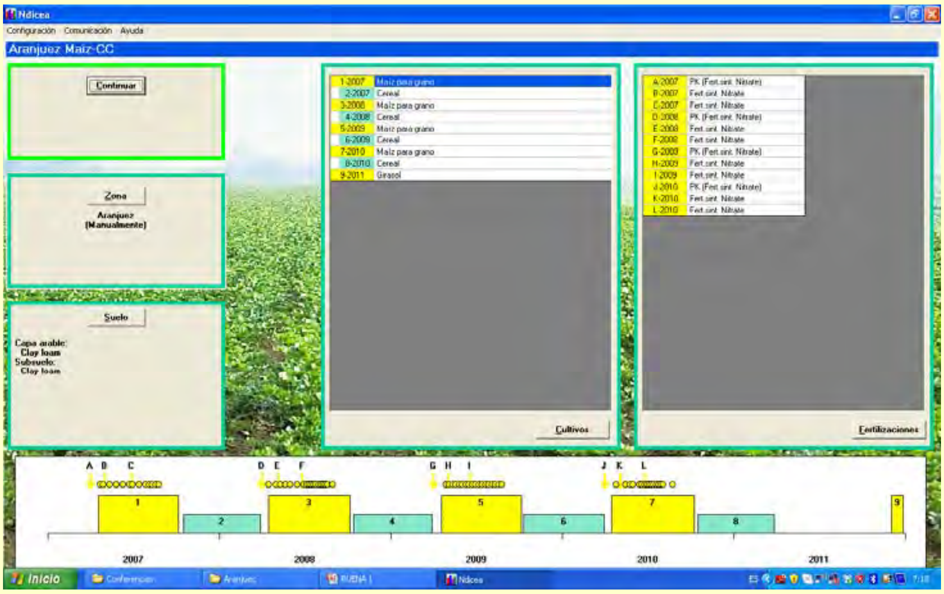


NDICEA: Aranjuez
Maíz-Barbecho

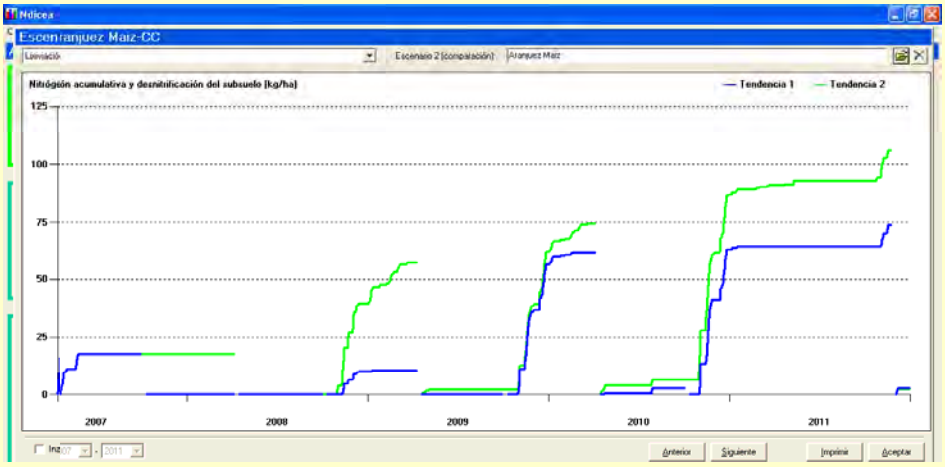
Resultados, Balance mineral

	N	P_2O_5	K_2O
Suministro por fertilizantes	184	90	30
Fijación de nitrógeno	0		
Deposición	5	3	8
Suministro total	189	93	38
Extracción por los productos	146	82	54
Excedente calculado	43	12	-16
Emisión	0		
desnitrificación	21		
lixiviación	68		
Acumulación de materia orgánica	-22,6		

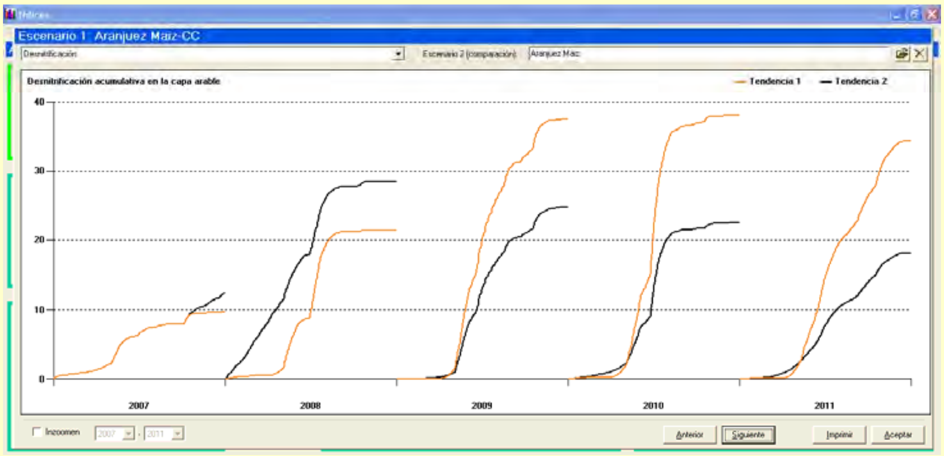
NDICEA: Aranjuez
Maíz-CC



NDICEA: Aranjuez
Maíz (línea verde) vs. Maíz-CC (línea azul)



NDICEA: Aranjuez
Maíz (línea negra) **vs. Maíz-CC** (línea marrón)



NDICEA: Aranjuez
Maíz-CC (Escenario 1) **vs. Maíz** (IEscenario 2)

Ndicea

Escenario 1: Aranjuez Maiz-CC

Balance mineral — Escenario 2 (comparación): Aranjuez Maiz

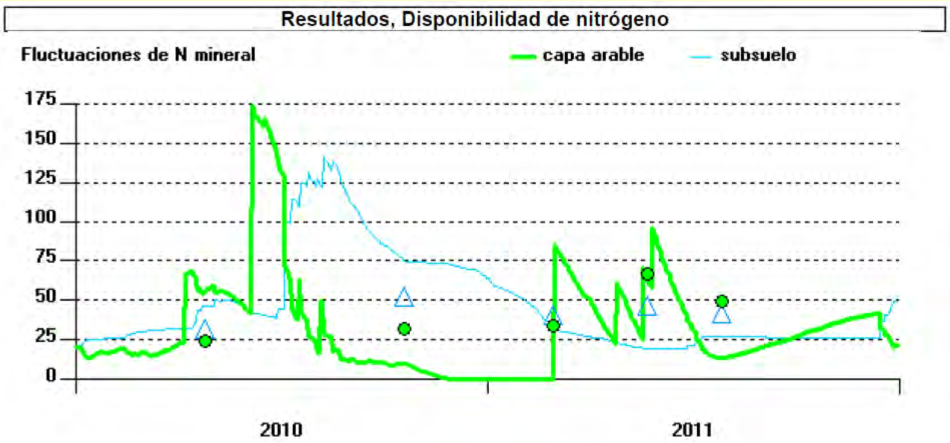
[Todo en kg/ha]	Escenario 1 N	Escenario 1 P_2O_5	Escenario 1 K_2O	Escenario 2 N	Escenario 2 P_2O_5	Escenario 2 K_2O
Suministro por abono	184	90	30	184	90	30
Fijación de nitrógeno	0			0		
Deposición	5 +	3 +	8 +	5 +	3 +	8 +
Suministro total	**189**	**93**	**38**	**189**	**93**	**38**
Extracción por productos	146 -	82 -	54 -	146 -	82 -	54 -
Excedente calculado	**43**	**12**	**-16**	**43**	**12**	**-16**
Volatilización	**0**			**0**		
Desnitrificación	**28**			**21**		
Lixiviación / desnitr. subsuelo	**50**			**68**		
N en acumulación de mat. org.	**1**			**-23**		

NDICEA: aplicación

- **Aranjuez: La Chimenea**
  Maíz vs. Maíz- CC (4 años)
- **Albacete: Las Tiesas (ITAP)**
  Maíz- Trigo (2 años)
- **Albacete: La Candelaria (ITAP-agricultor)**
  Maíz- Trigo (2 años)

NDICEA: aplicación

- **Albacete: La Candelaria (ITAP)**
  Maíz- Trigo (2 años)



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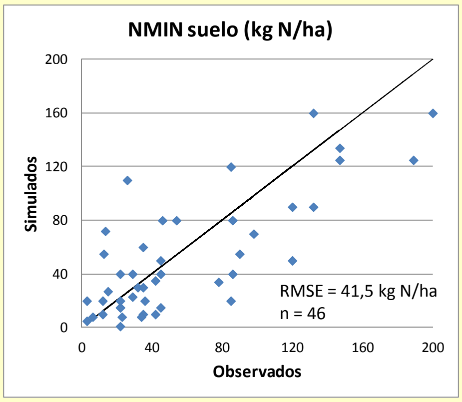

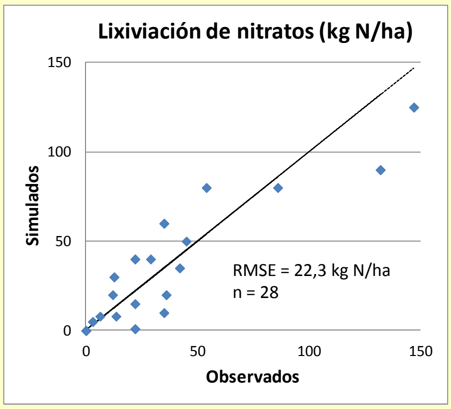

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- **Paso temporal: 1 día**
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- **Evapotranspiración: Adaptación FAO no. 56 (Allen et al. 1998)**
- **Movimiento agua en el suelo: modelo pistón con coeficiente retardo**
- **Mineralización MO: Modelo descomposición dos pools (Janssen 1996)**
- **Lixiviación nitratos: Producto agua percolada por debajo de raíces y concentración nitratos último horizonte (factor corrección)**
- **Desnitrificación: función desnitrificación potencial, contenido MO, disponibilidad nitratos, humedad (Bradbury et al., 1993)**
- **Volatilización amoniacal: Adaptación tablas USDA (Follet et al. 1991)**
- **Posibilidad calibración con datos medidos en campo**

Burgt et al. Nutrient Cycling in Agroecosystems. 2006. 74: 275-294
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NDICEA: ¿Para que NO sirve?

- Recomendación del fertilizante a aplicar durante la campaña
- Toma de decisiones a tiempo real

NDICEA: ¿Para que sirve?

- Obtener balances representativos de nutrientes en sistemas de cultivo específicos
- Diseño y comparación de estrategias de manejo de nutrientes: toma decisiones a medio plazo
- Inicio y base de discusión con agricultores, técnicos o estudiantes

¿Cómo obtenerlo?
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Registrarse

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- Proyecto NTOOLBOX:
  - **Catálogo de estrategias** para control de la lixiviación de nitratos
  - **NDICEA**: Modelo de simulación del balance de N en sistemas de cultivo